

# Study of Self-Reported Hypersensitivity to Electromagnetic Fields in California

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Cases of alleged hypersensitivity to electromagnetic fields (EMFs) have been reported for more than 20 years, and some authors have suggested some connection with the "multiple chemical sensitivity" illness. We report the results of a telephone survey among a sample of 2,072 Californians. Being "allergic or very sensitive" to being near electrical devices was reported by 68 subjects, resulting in an adjusted prevalence of 3.2% (95% confidence interval = 2.8, 3.7). Twenty-seven subjects (1.3%) reported sensitivity to electrical devices but no sensitivity to chemicals. Characteristics of the people reporting hypersensitivity to EMFs were generally different from those of people reporting being allergic to everyday chemicals. Alleging environmental illness or multiple chemical sensitivity diagnosed by a doctor was the strongest predictor of reporting being hypersensitive to EMFs in this population. Other predictive factors apart from self-reporting chemical sensitivity were race/ethnicity other than White, Black, or Hispanic; having low income; and being unable to work. The perception of risk of exposure to EMFs through the use of hair dryers (vs. exposure to power and distribution lines) was the factor the most associated with self-reporting about hypersensitivity to EMFs. However, risk perception was not sufficient to explain the characteristics of people reporting this disorder. **Key words:** electromagnetic fields, hypersensitivity. *Environ Health Perspect* 110(suppl 4):619–623 (2002).

<http://ehpnet1.niehs.nih.gov/docs/2002/suppl-4/619-623/levallois/abstract.html>

Self-reported electric and magnetic field sensitivity (SREMFS) has been described in the literature for nearly 20 years (Bergqvist and Vogel 1997). Most of the reported literature, mainly from Northern Europe, consists of case studies and limited population studies carried out in occupational settings (Levallois 2002). The published data concern essentially some nonspecific dermatological symptoms, mainly subjective (itching, burning, stinging, etc.) and associated with working near video display terminals (Lidén and Wahlberg 1985; Bergqvist and Wahlberg 1994). More recently, a general clinical portrait has been described in which neurasthenic symptoms (dizziness, fatigue, headache, difficulties in concentrating, etc.) seem to dominate, along with nonspecific skin disorders and ocular, gastrointestinal, or respiratory symptoms (Bergqvist and Vogel 1997; Knave et al. 1992; Bergdahl 1995). The common feature of this self-reported health disorder is its acute occurrence with proximity to electrical devices, including certain power lines, and its disappearance when the source is off or not nearby. Also striking is its variable severity, ranging from very mild symptoms to major impairment resulting in increased work absences and eventually unemployment (Bergqvist and Vogel 1997).

Few reports have been published on this issue in North America. Most are short review articles based on European literature (Fisher 1986; Cormier-Parry et al. 1988; Perry 1991), and a few case reports (Feldman et al. 1985; Rea et al. 1991). Based on the

European Commission working group survey (Bergqvist and Vogel 1997), the prevalence of SREMFS is low (from less than a few per million to a few tenths of a percent). However, this range of prevalence was estimated by questionnaires sent to occupational and environmental clinics and to support groups. In fact, no population-based studies for SREMFS have been published.

The literature reports a weak if any association of hypersensitivity with electric and magnetic field exposures (Bergqvist and Vogel 1997; Portier and Wolfe 1998; Leitgeb 1998). However, most of the provocation studies have been negative (Bergqvist and Vogel 1997). In particular, in blind exposure experiments, SREMFS subjects were not able to detect the presence of the fields at low intensities (Anderson et al. 1996; Oftedal et al. 1995). SREMFS sometimes has been considered a subset of a more general environmental illness and similar to multiple chemical sensitivity (Rea et al. 1991; Berg et al. 1992). Other authors have suggested that it is a manifestation of somatization or conversion of stress (Lidén 1996), but its association with perception of risk has not been studied.

As a result of this limited knowledge, a population-based study was conducted to fill some of these gaps. The main objective of this study was to estimate the prevalence of SREMFS in a random sample of adult Californians. It was also aimed at describing the characteristics of people with SREMFS as well as exploring its possible association to

self-reported chemical sensitivity (SRCS) and medically diagnosed chemical sensitivity (MDCS).

## Materials and Methods

### General Method and Population

This study is based on questions added from July 1998 to December 1998 to the 1998 California Adult Tobacco Survey (CATS). This survey is an ongoing monthly telephone survey that collects information on tobacco use and other health-related behaviors from a representative sample of the adult Californian population. A screened random-digit-dial sample purchased from a commercial sampling firm was used (California Department of Health Services 1999). Once a household was reached, all persons living in the household  $\geq 18$  years of age were enumerated and, if more than one was eligible, a computer-generated random selection algorithm was used to select the participant.

### Questionnaire

Questions regarding electromagnetic fields (EMFs) and chemical sensitivities were added at the end of the CATS questionnaire. SREMFS was defined as "allergic or very sensitive to getting near electrical appliances, computers or power lines." SRCS was defined as considering oneself "allergic or unusually sensitive to everyday chemicals" and MDCS as being "told by a doctor or other health professional that you had environmental illness or multiple chemical sensitivity." Self-reported history of asthma and hay fever as

This article is part of the monograph *Environmental Factors in Medically Unexplained Physical Symptoms and Related Syndromes*.

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This study was part of the California EMF research program, which is mandated by the Public Utilities Commission with moneys from California utilities. We thank B. Davis, Chief of the Computer Assisted Telephone Interviewing Unit of the California Department of Health Services, for her help. This work was conducted during a sabbatical by P.L. at the California Department of Health Services, Oakland, California.

Received 3 December 2001; accepted 15 April 2002.

well as reported perception of risk from EMFs was also assessed for each participant. A source of EMFs (either distribution power line or hair dryer) was considered risky for the participant if he or she agrees that "it could cause (either definitely or not) some disease." And it was defined as not risky if the participant considered that it was "definitely or probably safe." Other variables, extracted from the general CATS questionnaire, were age, gender, race, education, health plan coverage, employment status, and family income.

## Data Analysis

Prevalence rates were estimated using direct adjustment, with weights for age, gender, and race derived from the 1997 California Department of Finance population estimates of the 1998 California population (California Department of Health Services 1999). Characteristics associated with SREMFS were compared with those associated with SRCS to assess the similarities between the two conditions. Comparisons of proportions were done with chi-square analysis and the Fisher exact test. Factors associated with SREMFS in the total population were identified in crude analysis and then evaluated by multivariate logistic regression (Hosmer and Lemeshow 1989). Estimated prevalence odds ratios (PORs) are presented with 95% confidence intervals (95% CIs), and  $p < 0.05$  (bilateral test) is considered statistically significant.

## Results

We interviewed 2,072 adults for this study. The upper bound of the response rate (proportion of eligible households contacted that had a completed interview) was 84.1%. The response rate calculated according to the Council of American Survey Research Organization (CASRO 1982) was 58.3%. This method assumes that a proportion of households that could not be contacted represents potential eligible households. General characteristics of the 2,072 participants, compared with the 1990 California census, are presented in Table 1. The study sample

was different from the California population for some characteristics. Especially, the study sample contained more females and was slightly older than the California census population (Table 1). This confirms the need to adjust for the estimation of the prevalence of health disorders in the California population.

Among the 2,037 respondents to the EMF sensitivity questions, 68 reported SREMFS, resulting in a crude prevalence of about 3%. Adjusted prevalence of SREMFS was 32.4 per 1,000 (95% CI = 28.0, 36.8). Mean age of subjects reporting SREMFS was 43.4 years (range = 18–85 years), and mean duration of symptoms was 18.5 years (range = 1–55 years). Adjusted prevalence of people reporting SREMFS associated with necessity to change job or to remain unemployed was 5.20 per 1,000 (95% CI = 3.66, 6.75). Among the 2,063 participants who answered questions on chemical sensitivity, 503 (24.4%) reported SRCS. Adjusted prevalence of SRCS was 230.8 per 1,000 (95% CI = 221.9, 239.7), and lifetime prevalence of reported MDSCS was 33.9 per 1,000 (95% CI = 30.3, 37.5). Figure 1 shows that the two complaints do not totally overlap. About 40% ( $n = 27$ ) of SREMFS subjects did not also report SRCS, and 91.6% ( $n = 446$ ) of patients who reported SRCS did not report SREMFS. Yet 41 individuals (2.0% of all respondents) reported both conditions, and only 27 individuals (1.3% of all respondents) reported SREMFS without SRCS.

Because there was some overlap between SREMFS and SRCS, we compared the characteristics of participants reporting SREMFS ( $n = 68$ ) with those of participants reporting only SRCS ( $n = 446$ ; Table 2). Several differences between the two groups were striking. Compared with those reporting only SRCS, the SREMFS group had fewer females ( $p = 0.045$ ) and fewer Whites and more Hispanic or other races/ethnicities ( $p = 0.001$ ); were less likely to have a health insurance plan ( $p = 0.008$ ); had lower incomes ( $p = 0.029$ ); were most likely to be unemployed ( $p = 0.011$ ); were less likely to report asthma ( $p = 0.008$ );

and were more likely to report MDSCS ( $p = 0.013$ ).

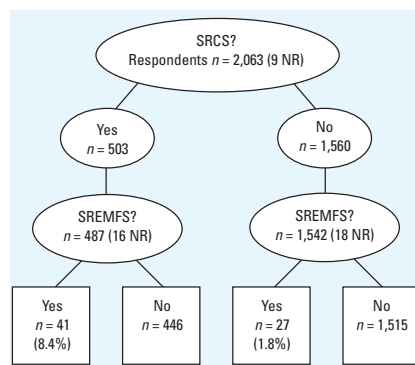
We also compared the characteristics of the subjects reporting only SREMFS ( $n = 27$ ) with those of subjects reporting only SRCS ( $n = 446$ ). The same tendency was found but with fewer statistical differences: subjects with only SREMFS included fewer females ( $p = 0.037$ ), were more likely to be unemployed ( $p = 0.038$ ), and were less likely to report hay fever ( $p = 0.002$ ) than were subjects with only SRCS. Even though there was some overlap between SREMFS and SRCS, these two disorders appear to be reported generally by different types of people.

SREMFS was then considered the dependent variable, and multiple logistic analysis was conducted to evaluate factors associated with it in the total population. Because age was not mentioned as a key variable in the published literature and was not associated with SREMFS in the crude analysis ( $p = 0.83$ ), it was removed from further analysis. The results of the multivariate analysis are presented on Table 3 along with crude results. Having SRCS or MDSCS was the strongest factor associated with SREMFS: POR = 3.6 and 5.8, respectively. This confirms the association between the two complaints. The other factors associated with SREMFS were being unable to work (POR = 3.8), earning less than \$15,000/year (POR = 2.4), and being from a race/ethnicity other than Black, White, or Hispanic (POR = 4.9).

Because risk perceptions for different EMF sources were very correlated, the effects of perception of risk from power lines, distribution lines, or hair dryers were then included separately in the model. Among those studied, perception of risk from hair dryer exposure was found to be the most strongly associated with SREMFS: adjusted POR = 2.4 (95% CI = 1.2, 4.9). Perception of risk from distribution lines was also associated with SREMFS but to a lesser degree: adjusted OR = 2.0 (95% CI = 1.0, 3.9). Possible effect modification of risk perception was evaluated. None of

**Table 1.** General characteristics of the 2,072 respondents of the 1998 EMF California study compared with 1990 California population.

Characteristics		Study sample		California population (%)
		<i>n</i>	%	
Age (years)	18–24	219	10.6	15.7
	25–34	486	23.5	25.9
	35–44	521	25.1	21.0
	45–54	345	16.7	13.1
	55–64	214	10.3	10.1
	≥ 65	287	13.9	14.2
Gender	Male	913	44.1	49.6
	Female	1,159	55.9	50.4
Race/ethnicity	White	1,251	60.4	61.4
	Hispanic	525	25.3	22.4
	Black	111	5.4	6.7
	Other	185	8.9	9.4



**Figure 1.** Answers to questions regarding SRCS and SREMFS. NR, nonrespondents.

the three indicators of EMF risk perception was found to be a significant modifier (using Breslow-Day test) of the associations described above. Finally, the possible confounding effect of risk perception was also evaluated. Association of SREMFS with specific subject characteristics remained quite stable after considering perception of risk from EMFs (Table 3), therefore confirming that perception of risk was not an explanation for the associations identified.

## Discussion

SREMFS has been described for a long time in the European literature but mainly based on case studies. This population-based study demonstrates that the prevalence of SREMFS (3.2%) is not at all negligible. Extrapolated to the total adult 1998 California population, it can be estimated that around 770,000 people perceive that they are sensitive to EMFs. Extrapolation to the total 1998 California population for those who decided to change jobs as a result of perceived hypersensitivity to EMFs is still not small, with an estimate of 120,000 of adult Californians.

Strengths of this study should be emphasized. First, to our knowledge, this is the first population-based study on EMF hypersensitivity. Inclusion of specific questions in a well-designed prevalence survey (California Department of Health Services 1999) results in a survey of a random sample of the California population. Second, we specified in the SREMFS questions the main sources of EMFs reported as potential sources of this disorder (electrical appliances, computers, or power lines) as identified by the European Commission working group (Bergqvist and Vogel 1997). Therefore, the SREMFS data reported here can be compared with previous report results. Finally, we were able to compare SREMFS with SRCS to assess similarities between the two conditions because we added to the survey specific questions on chemical sensitivities.

Weaknesses of the study should also be acknowledged. First, sensitivity to EMFs was self-reported and not clinically validated. This makes it difficult to assess how symptomatic or how life-impacted these persons are. However, published literature has also relied on self-reporting of hypersensitivity to EMFs because there are no clear clinical diagnostic criteria for the condition (Levallois 2002). Second, one may also wonder if the sample is representative of the adult California population. Although there was some discrepancy regarding age and gender status of the respondents compared with population data, we were able to adjust for those variables when estimating the prevalence of the conditions. The response rate (58–84%) was very acceptable for such a study, but it is always possible that some

subclasses of the California population were less represented in the sample. Particularly, it is well known that those responding to telephone surveys are more educated than nonresponders (Aday 1989). This is also true to some extent with responders in the present CATS survey (California Department of Health Services 1999). This should be considered in interpreting the results of this study because the reported SREMFS was associated with a lower socioeconomic status.

We can only compare our data with the estimation done by the European Commission group for the European population (Bergqvist and Vogel 1997) because this is the closest to a population-based approach. That study was based on a questionnaire sent to 138 centers of occupational medicine (COMs) and similar centers and 15 support groups from 15 different European countries.

Its objective was to estimate the prevalence of SREMFS in Europe. Response rates were low (49% for COMs) and questions were subjective, based on respondents' estimations of the total number of cases in the country of the COM. The estimated prevalence of SREMFS was from less than a few per million to a few tenths of a percent using as denominators the total of the population of each studied country and as numerators the medians of the estimations of the numbers of cases per country. The occurrence of severe cases was estimated to be one order of magnitude lower. Those estimations are well below what we report in our study. These may be underestimations because they are based on cases having had a contact with either an occupational clinic or a support group and hence have not captured those individuals not actively contacting these groups. Compared with the European

**Table 2.** Comparison of characteristics of subjects reporting SREMFS to of subjects those reporting SRCS only.

	SREMFS (n = 68)		SRCS only (n = 446)		p-values
	n	%	n	%	
Age (years)					
18–24	8	11.8	44	9.9	0.419
25–34	16	23.5	95	21.3	
35–44	17	25.0	104	23.3	
45–54	11	16.2	78	17.5	
55–64	4	5.9	67	15.0	
≥ 65	12	17.6	58	13.0	
Gender					
Male	28	41.2	130	29.1	0.045
Female	40	58.8	316	70.9	
Race/ethnicity					
White	19	28.4	233	52.2	0.001
Black	2	3.0	32	7.2	
Hispanic	31	46.3	142	31.8	
Other	15	22.4	39	8.7	
Education					
<12 years	23	33.8	88	19.7	0.094
High school graduate	15	22.1	106	23.8	
Some college or technical	15	22.1	130	29.1	
University graduate	15	22.1	122	27.9	
Employment status					
Employed	30	45.5	219	54.9	0.011
Out of work	5	7.6	23	5.8	
Not searching	22	33.3	141	35.3	
Unable	9	13.6	16	4.0	
Income (\$K)					
<15	26	41.3	109	26.7	0.029
15–24	14	22.2	69	16.9	
25–49	12	19.1	109	26.7	
≥50	11	17.5	121	29.7	
Health plan					
Yes	42	61.8	339	76.7	0.008
No	26	38.2	103	23.3	
Disease history					
Asthma					
Yes	9	13.2	126	28.3	0.008
No	59	86.8	320	71.8	
Hay fever					
Yes	42	61.8	324	72.6	0.084
No	26	38.2	122	27.4	
MDCS					
Yes	13	19.1	37	8.3	0.013
No	55	80.9	408	91.7	

**Table 3.** Factors associated with SREMFS among Californians.

	POR <sub>c</sub>	95% CI	POR <sub>adj</sub>	95% CI	POR <sub>adj+</sub>	95% CI
Gender						
Female (n = 1,139)	1.13	0.69, 1.85	0.68	0.38, 1.2	0.77	0.39, 1.52
Race/ethnicity						
White (n = 1,230)	1		1		1	
Black (n = 109)	1.80	0.52, 6.19	1.19	0.31, 4.57	1.15	0.28, 4.7
Hispanic (n = 517)	4.07	2.27, 7.27	1.99	0.93, 4.29	1.68	0.68, 4.15
Others (n = 181)	5.76	2.87, 11.55	4.94	2.28, 10.7	4.48	1.91, 10.5
Education						
University (n = 731)	1		1		1	
12 years of some college (n = 1,019)	1.45	0.77, 2.71	0.92	0.45, 1.86	0.84	0.38, 1.85
<12 years (n = 283)	1.02	2.06, 7.87	1.31	0.53, 3.26	1.02	0.33, 3.14
Employment status						
Employed (n = 1,333)	1		1		1	
Out of work/not working (n = 640)	1.79	1.06, 3.01	1.65	0.86, 3.15	1.60	0.77, 3.35
Unable to work (n = 61)	7.04	3.19, 15.50	3.79	1.39, 10.7	3.33	1.07, 10.33
Family income (\$K/year)						
≥25 (n = 1,288)	1		1		1	
15–24 (n = 262)	3.10	1.57, 6.12	2.18	1.00, 4.75	1.52	0.58, 3.99
<15 (n = 331)	4.09	2.64, 8.33	2.43	1.13, 5.24	3.00	1.28, 6.99
Health plan						
No (n = 373)	2.88	1.74, 4.77	1.07	0.55, 2.00	1.07	0.50, 2.30
Disease status						
Asthma (n = 281)	0.95	0.47, 1.94	0.35	0.14, 0.87	0.40	0.15, 1.06
Hay fever (n = 1,015)	1.65	1.00, 2.71	1.42	0.78, 0.20	1.36	0.69, 2.69
Self-reported chemical sensitivity (n = 487)	5.16	3.14, 8.48	3.63	1.98, 6.67	3.36	1.67, 6.76
Medically diagnosed chemical sensitivity (n = 73)	7.50	3.89, 14.47	5.80	2.61, 12.8	5.21	2.03, 13.6

Abbreviations: POR<sub>c</sub>, crude POR; POR<sub>adj</sub>, POR adjusted for all the variables prescribed in the table; POR<sub>adj+</sub>, POR adjusted for all the variables in the table plus perception of EMF risk from hair dryer use.

Commission estimation, our estimate is 10 times higher for the total of cases as well as for the severe cases (those deciding to change jobs or stop working as a result of this condition).

Our study indicates that SREMFS and SRCS may have different origins because they do not share all risk factors. Despite some important overlap between the two diseases, SRCS was much more prevalent than SREMFS, and there was a clear difference between subjects reporting SREMFS and those reporting only SRCS. In particular, differences in gender and allergic status were striking. The overrepresentation of females in patients reporting chemical sensitivity has been described several times (Interagency Workgroup on Multiple Chemical Sensitivity 1998). It was found particularly in California for SRCS but not for MDCS (Kreutzer et al. 1999). No association between reported SREMFS and gender was found in this study. The positive association between SRCS and allergic status (particularly with asthma) is well known (Kreutzer et al. 1999) but was not found for people reporting SREMFS (in fact, a negative association was found with asthma).

Although the two self-reported syndromes appear to be different, chemical sensitivity—either SRCS or MDCS—was found to be an important risk factor for SREMFS. The association between the two conditions has been proposed by authors on the basis that the two have common nonspecific symptoms (Lidén 1996), and symptoms of sensitivity to electrical

devices were reported by chemical-sensitive patients (Portier and Wolfe 1998).

Apart from SRCS and MDCS, three other factors were associated with reporting SREMFS after adjustment for co-variables: being unable to work, being from a race/ethnicity other than Black, White, or Hispanic, and having low income. Being unable to work might be a consequence of the disorder for the more severe cases. Being from a race/ethnicity other than Black, White, or Hispanic was a surprising risk factor. In California this group is mainly composed of Asians. No explanation was found for such an association, but this should be clarified further. Perhaps misunderstanding the question biased the response to yes for this group. However, because there is a difference in races between those reporting SRCS and those reporting SREMFS, the race association with SREMFS could be real. Finally, the association with low income is rather unexpected. The difference from those reporting SRCS confirms that it is specifically linked to reporting SREMFS. Low education and having no health plan were associated with crude POR but disappeared after using multivariate analysis. No explanation could be found for the association with low income.

Perception of plausible risk from EMF sources was found to be associated with SREMFS, particularly for hair dryer use and to a lesser extent for distribution lines. The association of risk perception from EMFs with SREMFS demonstrates the influence of

perception of risk that has already been described for other symptoms (Shusterman et al. 1991; McMarron et al. 2000). But the persistence of the previous identified associated risk factors when taking into account this possible confounder or effect modifier tends to support the fact that SREMFS is not explained by the perception of risk.

SREMFS has been described mainly in Europe. This is the first study to evaluate this problem in North America. On the basis of a population telephone survey, we found that about 3% of the California adult population self-reports being sensitive to sources of EMFs such as power lines, computers, or electrical appliances and 0.5% decided to change jobs because of it. Although no clinical confirmation of the reported symptoms was available, these data demonstrate that, because of its prevalence and possible life impact, this perception is of public health importance in California and perhaps in North America. The cause of this self-reported disorder is not known (Bergqvist and Vogel 1997; Anderson et al. 1996). Although some relation to EMF exposure may exist, there is some evidence of an important psychological component associated with this disorder, particularly for those reporting general symptoms (Bergdahl 1995). However, the present study showed that perception of risk is not an explanation for the reported syndrome. Moreover, characteristics of people reporting hypersensitivity to EMFs were generally different from those of people reporting chemical sensitivity.



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